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THE DEVELOPMENT OF ICONIC AND IMMEDIATE MEMORY IN ELEMENTARY SCHOOL CHILDREN

BY

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The undersigned certify that they have read, and recommended to the Faculty of Graduate Studies for acceptance, a thesis entitled "The Development of Iconic and Immediate Memory in Elementary School Children" submitted by Gerry Darrel Ewert in partial fulfilment of the requirements for the degree of Master of Education.

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ABSTRACT

The effects of five variables in Iconic and Immediate Memory in elementary school students (sex, age, grade, exposure time, and stimulus density) were studied using a simultaneous presentation of consonant letter stimulus items and immediate recall. There were an equal number of males and females in the sample. The age of the subjects ranged from six to twelve years of age, and the grade ranged from One to Six. Each grade contained two age groups. The remaining variables were assigned the following parameters: exposure time (recognition level for letters, 3, 6, and 9 seconds per display), stimulus density (6 and 12 letters per display). The data were collected individually from 240 subjects (20 subjects per each age-grade combination) using tachistoscopically controlled exposures and oral recall.

The results indicated that all variables, with the exception of the sex of the subject, were significant factors in Iconic and Immediate Memory. As age and grade increased, recall on all tasks increased significantly. The results of increasing exposure time and stimulus density on recall indicated that the younger subjects (up to eight years of age in Grade Three) tended to recall fewer letters whereas the older subjects tended to increase the number of letters recalled. The results suggest that the subjects in Grades Three to Six demonstrate a fully developed Iconic Memory capacity but only the subjects in Grade Six demonstrate a functionally developed Immediate Memory capacity for the storage and recall of letters.

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CHAPTER I

INTRODUCTION

The ability to remember previous experiences, particularly prior to learning situations, is perhaps the single most important factor in the survival of any species. Through previous experience and acquired methods of problem solving, memory dictates the present sum total of any individual's personality, knowledge, and morals. It has often been stated that present learning is built upon prior learning. It is, in fact, more correct to say that present learning is only made possible by the recollection of prior learning. Without the ability to remember it is impossible to learn.

The process of education is essentially the transmission of information from various sources (teachers, books, and audiovisual materials) to the student. The material presented to the student is to be learned. The criterion of this learning is the ability to remember the material at the appropriate time. It would then seem that educators, who spend much of their time discussing the learning of material, would be better advised to discuss how the student learns effective methods of remembering the material. This is not a simple problem with a simple immediate solution. It is necessary to examine the concept of memory, then to examine the development of part of this concept within the elementary school. The present study was designed to provide some

information on the development of memory abilities and capacities in elementary school children.

Historical Background. The general concept of memory has a long history dating back to the early Greeks. The credit for the invention of the art of memory is given to Simonides of Ceos (556 to 468 B.C.) by the Ad Herrenium, Cicero's De oratore, and Quintilian's Institutio oratoria (Yates, 1966). The art of memory became a part of rhetoric as a technique by which an orator could selectively improve his memory. This memory, which was greatly improved by training, was called 'artificial' memory. This 'artificial' memory was distinct from natural memory - which from the brevity of reference in the Ad Herrenium, was of little interest to the teachers of rhetoric. However, the rules and precepts for improving one's memory, as described in the Ad Herrenium (86 to 82 B.C.) are as valid today as they were then (Norman, 1969). Yet, to stop at this point to apply these mnemonic techniques in our classrooms to teach our students how to remember would be a mistake. It may indeed significantly improve the students' performance on exams, but our interest should focus more on the intelligent use of the material learned, rather than on just the storage of the material. Although interest in the art of memory has continued to the present day, there has been a shift in the conceptual approach to memory. This change may be best described as a shift in emphasis from 'artificial' to

natural memory, or in other words, from the art of memory to the science of memory. This change in perspective has produced a corresponding change in emphasis from how to remember, to how memory functions.

Conceptual Shift. In North American psychology the recognized introduction of memory as a subject for scientific study was made by William James (1890) in the Principles of Psychology (in Norman, 1969). James developed a conceptual approach to memory which guided much of the thinking that followed him. He emphasized such things as attention, primary memory, and secondary memory. The interest in this study is with the elaboration of primary memory. Primary memory is the more immediate memory and is subject to rapid decay. Primary memory evidently occurs prior to secondary memory, which is less direct and more resistant to decay. The work in the area of memory following James has greatly elaborated his basic conceptual model of the structure and functioning of man's memory. Sperling (1960) refined primary memory into two stages: 1) a rapidly decaying sensory image, and 2) an immediate or working memory. This refinement has given psychology the three stage model of memory generally accepted by most contemporary researchers (Kumar, 1971). An additional conceptual refinement was added by the application, in the early 1950s, of information processing theory to the area of memory (Norman, 1969). Norman suggests that this did much to develop the concept of memory as an

active participant in the processing of information. The active concept of memory has led Miller (1956) and Sperling (1960) to examine the amount of information the different stages of the memory model can process. In general, these researchers have concluded that there is a measurable maximal number of items the memory system can process at one time, as measured by the recall of stimulus items.

Purpose of this Study. In summary, the art of memory has given way to the science of memory. This science of memory has developed a basic concept of the structure of memory as comprising three stages: 1.) Sensory Register (SR) or Iconic Memory (IcM), 2.) Short-Term-Memory (STM) or Immediate Memory (IM), 3.) Long-Term-Memory (LTM). These stages can be distinguished from each other by time and space (Keele, 1973). The time variable is the amount of time necessary to establish a memory trace at each stage and, perhaps more pertinent, the duration of the trace. The space variable is the capacity of each stage for information processing. Intimately interwoven with this structural concept of memory is the question of how information is processed. The concepts of Iconic and Immediate Memory have been primarily developed with data from adult subjects. This has, while elaborating the model, provided little information about the development of Iconic and Immediate Memory in children. The primary objective of this study is to establish normative data on the amount of information that elementary school subjects can process at these two stages of the memory model.

CHAPTER II

REVIEW OF RELATED LITERATURE

The general area of memory encompasses two basic conceptual approaches. One approach is interested mainly in the structure of the memory process. The other is primarily concerned with the processing of information within the structure of the memory system. The most common research focus appears to be a combination of these two approaches, and it is this latter orientation that is used in the present study.

Basic Model of Memory. Kumar (1971) reviewed most of the current literature on the structure of memory and concluded that until further evidence is available to the contrary, the multistorage model of memory is the most acceptable. This model, as shown in Figure 1, has three

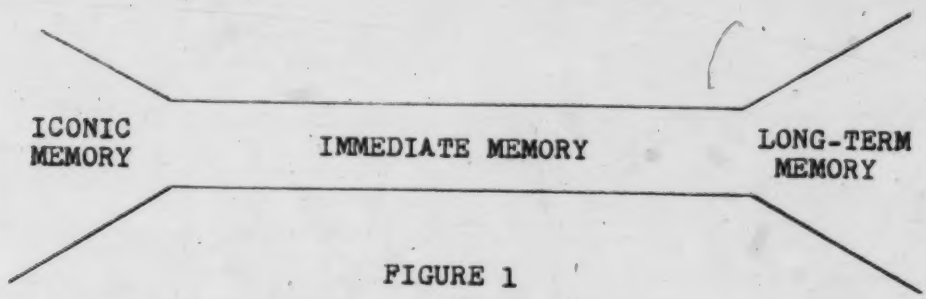

FIGURE 1

GRAPHIC REPRESENTATION OF THE BASIC MEMORY MODEL

storage levels: 1.) Iconic Memory (IcM), 2.) Immediate Memory (IM), 3.) Long-Term Memory (LTM). Although the choice of terms may appear arbitrary, the use of the term Iconic Memory, rather than Sensory Register, is based upon Neisser's (1967) concise description of Iconic Memory. The use of the term Immediate Memory, rather than Short-Term Memory, is based on Norman's (1969) distinctions between methods of stimulus presentation and recall conditions. Short-Term Memory tasks have typically used a serial stimulus presentation with multiple exposures until all stimuli are correctly recalled. The third stage of memory, Long-Term Memory, was not directly involved in the tasks used in this study and will therefore not be discussed.

Although greater elaboration of the basic model shown in Figure 1 has occurred (Norman, 1967, Sperling, 1967) the primary interest of this study was not in the refinements but in this very basic model itself. In this model the processing of information proceeds from left to right, that is, information coming in from the senses is processed through the Iconic to Immediate and finally to Long-Term Memory. Not all information is processed. Loss of information occurs at each level either through decay, or selection. The capacity of Iconic Memory is larger than the amount of information transferred into Immediate Memory (Sperling, 1960). At the Iconic level of processing the loss of information is primarily due to the rapid decay of the visual trace (Neisser, 1967), however, in the case of

partial reports (Sperling, 1960, Averbach and Coriell, 1961) the loss of information also occurs due to the selection of specific items for recall. In Immediate Memory, the loss of information is primarily due to the lack of rehearsal of the items (Norman, 1969, Kumar, 1971).

Limitations of the Literature. The major difficulty encountered while reviewing the literature was the lack of previous studies examining the development of Iconic and Immediate Memory in elementary school subjects. While on one hand this lacuna lends itself to creative thinking, it does severely limit the applicability of previous research in the present study. Since most of the previous data was obtained from adult subjects, only those articles having direct empirical or theoretical application to the present study will be used.

Iconic Memory

Neisser in Cognitive Psychology (1967) introduced the terms "icon" and "Iconic Memory" as descriptive of part of the memory process. The icon is the visual image or impression which continues in subjective experience even after the stimulus, which initiated the experience, has been terminated. The continued processing of the information

stored in the icon is Iconic Memory (IcM). Neisser's own description of this stage of memory is concise:

> The "persistence" of visual impressions makes them briefly available for processing even after the stimulus has terminated. This stage of memory is here called "iconic memory". (Neisser, 1967, p.15)

Earliest Description. The realization that the experience of a stimulus continues after the stimulus has been terminated is not a new idea to psychology. William James stated:

> As a rule, sensations outlast for some little time the objective stimulus which occasioned them. (James, 1890, p.645)

James, however, did not consider this phenomena a part of memory, but rather as a primary after-image. Fechner (in James, 1890) labelled the phenomena as a memory-after-image and distinguished them from ordinary after-images by the following characteristics:

1.) Their originals must have been attended to, only such parts of a compound original as have been attended to appearing. This is not the case in common visual after-images.

2.) The strain of attention towards them is inward, as in ordinary remembering, not outward, as in observing a common after-image.

3.) A short fixation of the original is better for the memory after-image, a long one for the ordinary after-image.

4.) The colors of the memory-after-image are never complimentary of those of the originals. (James, 1890, footnote p.645)

Fechner's first two points (the emphasis on attention and remembering) place this after-image phenomena properly as a part of the memory process. In Neisser's terms this memory-after-image is an icon, a very transient record of the stimulus which permits the continuation of processing. Fechner's third point (exposure duration for maximal results) has oriented much of the research following him to use tachistoscopically controlled exposures of short durations in examining this phenomena. The final point that Fechner raises has important implications for the pre- and post-exposure fields used in the testing situation.

Clarification of Capacity. A very old tachistoscopic experiment was the span-of-perception experiment which attempted to determine the maximum number of items the subject could recall after a glance (Averbach and Coriell, 1961). The experimenter would briefly present cards with an increasing number of stimulus items until the subject began to make errors. The span-of-perception was taken to be the number of items the subject could report perfectly and has been historically treated as the Iconic Memory capacity (Sperling, 1963). For adult subjects this capacity is quite consistent at 4 to 5 stimulus items (Sperling, 1960, Averbach and Coriell, 1961), however, the use of partial reports in recall, in which a matrix of stimulus items are displayed with a particular row or column of items cued for recall

following the termination of the stimulus, places the absolute amount of information stored in the Iconic Memory capacity at 12 or more stimulus items for adult subjects (Sperling, 1960). The term "capacity" is used in this study in its historical sense (Averbach and Coriell, 1961). Iconic Memory capacity has been determined by the number of stimulus items correctly recalled immediately following a brief exposure of the stimulus items (Sperling, 1963). For Iconic Memory, the capacity established by the free recall of stimulus items briefly displayed would indicate the recoding capacity from the rapidly decaying visual trace into verbal storage for recall (Sperling, 1960). This recoding capacity may more easily be conceptualized as the transfer capacity, the amount of information that can be transferred (recoded) from the rapidly decaying visual trace into verbal storage for oral recall. This transfer capacity of Iconic Memory is, in this study, of more interest than the absolute capacity, as established by estimations from the partial report recall method used by Sperling (1960) and Averbach and Coriell (1961). Although the actual size of the Iconic Memory capacity may be no different between subjects in elementary school, the amount of usable information that can be recoded from the absolute capacity may change as age and grade levels change. Since previous studies have used only adults as subjects, the "transfer capacity" has not been of interest as much as the "absolute capacity". However, the lack of evidence

with children as subjects orients the present focus on "transfer capacity", since this variable may directly affect changes in recall levels for both the Iconic and Immediate Memory tasks. It is this focus that the present study wishes to emphasize.

Perceptual Factors. The span-of-perception approach raises two basic questions. First, it must be established what exposure duration constitutes a 'glance'. Secondly, it must be determined the extent to which this phenomena is a perceptual rather than a memory factor. Once the perceptual factors are controlled for, it would be possible to examine the development of the transfer capacity of this stage of the memory process.

Averbach and Coriell (1961), and Sperling (1960) appear to equate the terms "glance" and "fixation" in terms of duration. In order to establish the amount of information processed per fixation very brief exposure of visual material were typically used. The subject fixed his eyes before the exposure of the stimulus material with the exposure duration less than the reaction time of the eye for a change in fixation. Sperling (1960) makes the point that the eye assimilates information only in the brief fixation pauses between saccadic movements. The saccade is defined as the time taken to move from one fixation to another. Mackworth (1962) reports that the average saccade and fixation time is 200 to 250 milli-seconds (msec).

However, the data on saccade and fixation times are on adult levels of performance which may not correctly reflect an elementary school subject's capabilities. A further consideration is that each fixation for different subjects may encompass a different visual area size (Shiffman, 1972). Brackbill (1967) states that the child's visual system cannot adapt and process information as efficiently as the adult's. Haith (1971) states that while children are not perceptually slower than adults they cannot adequately deal with all of the information presented to them. Whether this is a maturational or experiental effect is at this point not amenable to a definite solution. On the one hand, these differences may be due to the maturation of the visual system in terms of the rate of processing or the usable retinal area. On the other hand, experience with the material to be used as stimulus items may increase the amount of information processed per fixation due to increased facilitation with the stimulus items. Visual recognition is dependent upon hierarchial feature analysis and cross modal integration (Pribram, 1971). The way that an individual knows an 'A' is an 'A' involves the coding of the retinal information then successive decoding through the visual system to the area of the striate cortex. At this point the visual stimulus has been analyzed in terms of subordinate impulse generation which are then integrated and passed on to the visual association cortex (Grossman, 1967). The impulse pattern from the visual association cortex is then trans-

mitted to the audiovisual association cortex where the pattern of the impulses from the visual mode are translated into its learned correspondence with its audio-verbal correlate for oral recall (Pribram, 1971). This correlation between the visual stimulus and the oral response is a learned connection.

Effect of Perceptual Development. The effect of the integration of the visual stimulus and the oral response on the performance of elementary school children on Iconic Memory tasks may be that the visual system processes information more efficiently with practice and that the experiential training of the visual-auditory interconnections may increase efficiency. The child before entering school has a large functional vocabulary and can usually recite the alphabet. Therefore, before the child learns the visual symbols he has already coded the auditory stimulus in a retrievable form. The problem for the student in the early grades is essentially one of matching the symbol to the sound. The child knows the sound of the letter 'A' but must learn to associate the visual stimulus 'A' to the sound 'A'. If this is a learned connection there should be a significant improvement in Iconic and Immediate information processing capacity for letters from Grade 1 to Grade 6.

Exposure Duration. The saccade phenomena is also relevant for it demonstrates that visual processing of information is

in sequential segments. There are discrete segments processed from fixation to fixation, producing a continuous perceptual experience in consciousness. Further, minute oscillations or microsaccades occur during each fixation which prevents the habituation of the photosensitive cells in the retina. This maintains a maximal level of stimulation for continuous perception. If the visual stimulus was to be stabilized on the retina, perception would be a process of seeing and fading depending on the thresholds of the particular photoreceptors involved. This process of perception suggests that brief tachistoscopic exposures are not an 'unnatural' method of examining the amount of information processed in a 'glance' or perceptual segment. Although Sperling (1960) reports that exposure time variations between 150 to 500 milliseconds is not a significant parameter in determining the number of letters correctly recalled, Mackworth (1962), however, reports otherwise. Mackworth found that the number of digits reported out of ten stimulus items increased significantly up to an asymptotic level at 500 milliseconds. However, further increases in exposure time up to .14 seconds (1,400 milliseconds) had little effect on the number of items correctly recalled. These differences may be due to the difference of stimulus items, or they may reflect the difference between Sperling's trained subjects and Mackworth's subjects. This disagreement, on the most effective exposure level for examining Iconic Memory, may be best resolved by presenting the

stimulus items to the subject at the exposure level at which the subject can first extract information from the stimulus items presented. This was operationally defined as the exposure level at which the subject could recognize letters as letters.

By cueing the subjects for all brief stimulus presentations and requiring the immediate verbal recall of the items seen, Fechner's first two points (attention and remembering) can be satisfied. Fechner's third point, concerning the best method for establishing the icon, can be satisfied by the use of the exposure time at which each subject can first recognize the stimuli. This procedure produces the shortest possible fixation of the original stimuli for each subject.

Exposure Fields. Fechner's fourth distinction has implications for the pre- and post-exposure fields used during testing. The establishment of the icon depends upon the intensity of the illumination, the exposure duration, and the pre- and post-exposure fields (Averbach and Coriell, 1961, Neisser, 1967, Sperling, 1960). The intensity of the illumination of the visual display affects the icon since the retinal reaction to intense illumination is more active than to low illumination. This intense reaction prolongs the useful duration of the icon by rendering it more legible after the cessation of the stimulus. However, when a reasonable level of legibility is established,

increasing the brightness, sharpness, and contrast apparently does not affect Iconic Memory performance (Averbach and Coriell, 1961). The effect of intense illumination can be reduced dependent upon the pre- and post-exposure fields. If dark pre- and post-exposure fields are used, the useful icon memory duration may be prolonged for as long as five seconds (Sperling, 1960). Sperling (1960) compared bright and gray post-exposure fields and found significantly higher recall for the gray post-exposure field. At 150 and 500 milliseconds, recall for the gray post-exposure was 4.3 and 4.3 letters respectively. In both of these conditions the pre-exposure field was gray. The use of a dark pre-exposure field would tend to intensify the effect of any particular level of illumination which could affect the establishment of an icon. This effect may have produced a perceptual after-image particularly if a dark post-exposure field is used. It seems more relevant, however, to use the same illumination intensity in the pre- and post-exposure fields to reduce the possibility of spuriously inflating recall in Iconic Memory.

Stimulus Density. Although Haith (1971) reported a lack of significant age differences in visual processing speed for single geometric figures presented tachistoscopically, Haith did report significant differences in recall between younger and older subjects for presentations of multiple stimuli.

Teichner and Sadler (1962) found that at brief exposure times (up to 500 milliseconds) item recall for adults was positively related to stimulus density. If, as Haith's results indicate, increased stimulus density is negatively correlated with recall in younger subjects, the development of Iconic Memory may be best investigated by establishing the particular age-grade level at which recall in an Iconic Memory task is positively related to stimulus density. If, as the results reported by Teichner and Sadler (1962) and Haith (1971) suggest, the positive relationship between recall and stimulus density is a major distinguishing feature in comparing the recall of the mature with the younger subjects, one could, therefore, hypothesize that subjects whose recall increases as stimulus density increases, have a functionally developed Iconic Memory. The capacity of Iconic Memory may not be the same as the adult level of performance, for those subjects demonstrating a functional similarity by their recall being positively related to stimulus density, but their performance would be indicative of Iconic Memory development.

Immediate Memory

The term "Immediate Memory" (IM), as stated previously, is used in this study to avoid the possible confusion of methodology if the term "Short-Term Memory" was to be used. The typical Short-Term Memory study would use a serial presentation of single stimulus items. The exposure

time per item would therefore be contolled and recall would be either immediate, or delayed. The measurements recorded would be the number of trials required for the perfect recall of all the items in the list or, in the case of delayed recall, the number of items recalled from the original list after the subject had engaged in an interposed task. In contrast to the Short-Term Memory task, the Immediate Memory approach is not concerned with how many trials are required before a subject achieves perfect recall, rather, this method is concerned with the number of items a subject can recall after one simultaneous exposure to the items. Blankenship (1938) defined memory span as the ability of an individual to reproduce immediately, after one presentation, a series of discrete stimuli in their original order. This latter approach is the one the present study will be using.

Factors Affecting Development of Immediate Memory. The development of Immediate Memory is dependent upon more than one factor (Corsini, 1971). It is the position of this study that Iconic Memory is one factor involved in the development of Immediate Memory. Corsini (1971) states that the development of the ability to use mnemonic strategies in a task-oriented problem solving way, is definitely a major factor involved in the development of Immediate Memory. This suggests a method of testing subjects which assumes that the differences in recall obtained would be due to the development of mnemonic strategies in Immediate Memory.

Storage. Belmont and Butterfield (1971) reported that the younger subjects can take in all of the information presented but they are unable to adequately deal with the information for efficient recall. Dornbush and Basow (1970) reported that young subjects in elementary school did not operate on memory tasks, or in reading, in terms of storage rather, they ignored what they could not immediately handle. In both cases the term "young" appears to refer to subjects about eight years of age and less. These results seem to suggest that the Immediate Memory capacity limitation could be properly placed on the storage of the information rather than on the processing of the information. Belmont and Butterfield, and Dornbush and Basow both state that the younger subjects can process the information, therefore the limitation must be at the storage level of the memory process. However, it may be argued that the younger subjects could not read the visual stimuli as quickly as the older subjects, thereby lowering the actual rehearsals of the stimuli, which could produce a lowered recall amount.

Age and Grade. The capacity of the Immediate stage of memory has been set at 7 plus or minus 2 by Miller (1956) and at 5 items by Spitz (1972). The absolute level of adult Immediate Memory capacity which both Miller and Spitz are referring to is of little relevance to the present study. It was not the intention of this study to compare the performance of elementary school subjects on Immediate

Memory tasks to the performance of adults on the same tasks. It was, however, the intention of this study to examine the development of, and to provide normative data on, the Immediate Memory capacity of elementary school children. The finding that recall on Immediate Memory and Short-Term Memory tasks is positively related with age has been well established (Blankenship, 1938, Dornbush and Basow, 1970, McCarver, 1972). These findings did not, however, attempt to distinguish between the age and educational effects on the development of Immediate Memory. Subjects of the same age level, but in different grade levels, may not perform as a group on Immediate Memory tasks. The difference in grade level may be reflected in a difference in recall on Immediate Memory tasks. If the subject in the higher grade recalled more letters than their age-mates in the lower grade, one could conclude that the increased exposure of the subjects in the higher grade level to learning situations did significantly affect performance of subjects on this Immediate Memory task. If, however, no significant grade difference existed one could conclude that the grade level alone was not a significant factor in the development of Immediate Memory.

Stimulus Density. There is one further point concerning the age-related increase in recall in Immediate Memory tasks that must be considered. Corsini's (1971) statement that the development of Immediate Memory is directly related to

the ability to use mnemonic strategies has been referred to earlier. The problem in the present study was to demonstrate that the increased recall, that has been related to age increases (Blankenship, 1938, McCarver, 1972) may be due to the development of mnemonic strategies for recall in Immediate Memory. Perhaps the most effective method to resolve this dilemma would be the use of two stimulus densities. One stimulus density with a relatively light information load of six letters, the other with a relatively high information load of twelve letters (which would be well beyond the capacity of any of the subjects to recall completely). The recall for the complex stimulus array of those subjects, with mnemonic strategies for processing complex stimulus arrays, should be significantly greater than the recall of those subjects lacking the necessary mnemonic strategies. The difference in recall may also be demonstrated between the subject's recall for the two stimulus densities at the same exposure time. A further comparison is possible through the examination of the recall for both stimulus densities over a variety of exposure times. If the recall for the low density stimulus array is always greater than the recall for the high density arrays, one could conclude that the necessary mnemonic strategies for processing the high information arrays may not have been developed. Further, if the recall for the high or low density arrays did not increase, or in fact the amount recalled decreased as the exposure time increased, this result would seem most indicative of the lack

of development of the necessary mnemonic strategies. Therefore it may be postulated that the age-grade level at which the subject's recall of the stimulus items for the complex array increases as the exposure time increases, would indicate a functionally developed Immediate Memory.

Other Factors. The factors that affect performance on memory span tasks have been adequately reviewed by Blankenship (1938). The factors mentioned by Blankenship were considered in the design of the present study and are discussed in detail in the following chapter.

Summary

The comparison of the performance on the Immediate Memory tasks between those subjects who demonstrate Iconic Memory development to a functional level, and those subjects who do not show this development, may reveal the importance of the development of Iconic Memory to the development of Immediate Memory. Is the development of a functionally effective Iconic Memory a prerequisite for the development of an effective Immediate Memory? If this is indeed the case, the descriptive model of memory processing would be also applicable as a developmental model.

The development of Immediate memory has been discussed in the literature on a theoretical or age-related basis. The first approach has little empirical validiation, the second approach is an over-simplification of a very complex phenomena. The present study attempts to specify

the effects of age and grade on the development of Immediate Memory, as indicated by the subject's ability to recall an increasing number of stimulus items as the stimulus density and exposure time increased. Further, the possible effect of the development of Iconic Memory on the development of Immediate Memory was examined in terms of the use of the basic structural model of memory (as shown in Figure 1) as a model of memory development.

CHAPTER III

DESIGN RATIONALE

The purpose of this chapter is to outline the rationale for the experimental design used in the present study. Blankenship (1938) presents a thorough list of factors that affect performance on memory tasks.

Extrinsic Factors (from Blankenship, 1938)

1.) The characteristics of the material used as stimulus.

(a) Blankenship reports that in general the most difficult material to recall is nonsense syllables, then letters, then digits, sentences and related words, in that order. However, Blankenship refers to Bourdon's (1894) results that letters were easier for children to recall than other materials. The present study used consonant letters as stimulus items. The stimulus groupings were corrected for meaningful series of letters such as T.V. or N.H.L., in order to avoid an artificially inflated recall score. The use of digits for measuring either the Iconic or Immediate Memory capacity was rejected on the basis that verbal rehearsal of numbers can produce groupings of numbers particularly with simultaneous presentation, which would tend to artificially inflate the recall scores obtained. Further, the applicability of the memory capacity for digits

is more restricted than is the memory capacity for letters.

(b) Blankenship states:

> If the visual method is used, the material should be presented either one unit at a time (successive presentation), or all units at the same time (simultaneous presentation), for grouping would make it too simple for the subject to secure a memory span above his "true" one. (Blankenship, 1938, p.8)

In the present study the stimuli for each trial was presented simultaneously for both the Iconic and Immediate Memory tasks. This method will allow a comparison between the development of Iconic and Immediate stages of the memory process. Further, the simultaneous method of stimulus presentation has simpler instructions for the subjects and is an easier task for the subject to understand than would the successive method of stimulus presentation.

(c) Blankenship states that all the subjects should have the same degree of familiarity with the stimulus items. In the present study it is impossible to assume that a subject in Grade 1 will have the fluency and familiarity with letters that a subject in Grade 6 will demonstrate. In the present study each grade level, which is an indication of the level of familiarity with letters, is divided into two age groups. This permits a comparison within grades of the effect of maturation and also allows the comparison between grades of the same age in order to establish the effect of increased exposure to and manipulation of letters which are used as stimulus items.

2.) The rhythm of the presentation of the material.

Blankenship states:

> The effect of rhythm is to group the units in the series, again enabling the individual to secure a span higher than his "true" one.
>
> (Blankenship, 1938, p.9)

In the present study the letters used were all consonant to reduce the pronouncibility and rhythm of the stimulus arrays. The randomization and the correction of alphabetical order and meaningful groupings should reduce the rhythm of the letter arrays used in this study.

3.) The rate of presentation of the stimulus.

Blankenship appears to discuss the rate of presentation in terms of serial presentation of single items. However, he refers to Lightner Witmer who stated that the speed best adapted to the individual should be used. This is the method used in testing Iconic Memory. For Immediate Memory tasks three different exposure durations were used to examine the exposure time on recall since no definite method of determining the most appropriate exposure duration was found in the literature.

4.) The method of scoring the responses.

Blankenship reports that of the articles he reviewed all of the researchers appeared to use a different scoring method. For Iconic Memory the letters recalled, after each presentation, that were in the original display were counted as correct. This gave an absolute number of letters recalled per trial. In consideration of the very brief exposures used and the possibility of any one measure of Iconic capacity

being unrepresentative of the subject's true capacity, three trials were given for each stimulus density array. The average score over the three trials and the maximum number of letters recalled of the three trials were used as data for analysis.

For Immediate Memory the scoring method used by Sperling (1960) in which the total number of letters recalled in the correct serial order were scored as correct. This scoring method was reported by Sperling to be less subject to guessing and is more readily interpreted.

5.) The physical state of the subject.

Blankenship lists as separate factors the fatigue, illness, and drug use of the subject. In the present study no subjects were tested if they were using medication, or had recently recovered from an illness. Further, no subjects were tested directly following their engaging in a strenuous physical activitiy.

6.) The time of day.

Blankenship reports that:

> In order for the subject to perform in his best possible manner, the test should be made in the forenoon.
>
> (Blankenship, 1938, p.11)

In the present study all testing was done during afternoon school hours which was between one and three-thirty p.m. The effect of testing in the afternoon was similar for all subjects and is considered irrelevant to the inter-group comparisons made from the present sample.

7.) The attitude of the subject.

Blankenship reports that the attitude of the subject has a definite effect on his performance on memory span tasks. All subjects were excluded from the present study who directly stated or indirectly intimated by consistently disregarding instructions that they did not wish to participate in the study.

8.) The effect of distractions.

Blankenship states the obvious in clear terms:

> Inasmuch as attention is one of the processes involved in the successful functioning of memory span, if the process of attention are directed towards some other stimulus, they cannot operate effectively in the memory span function. (Blankenship, 1938, p.11)

The subjects in the present study were tested in either the Public Health Nurse's room or, in one school, in an unoccupied Vice-Principal's office. These rooms were generally quite removed from classroom and other noise and were very quiet. During testing there was no talking while the stimuli were presented or during recall of the items by the experimentors.

9.) The effect of practice.

The present study was not long enough nor were the same stimuli repeated with the same subject in testing recall therefore this factor is considered irrelevant to the present study.

10.) The effect of subjective grouping.

Blankenship reports Martin and Fernberger's (1929) finding that any memory span over 5 items was obtained

through subjective groupings of the stimuli. In the present study the use of subjective groupings by any subject to obtain a higher recall score is considered to be an example of the use of a mnemonic strategy. This use of a tactical rehearsal strategy is one of the indications of the development of Immediate Memory (Corsini, 1971) which is one of the interests of this study.

Intrinsic Factors (from Blankenship, 1938)

1.) The age of the subject.

Blankenship states:

> The age of the individual is a factor which definitely affects memory span. (Blankenship, 1938, p.14)

Although Blankenship is quite definite that there is an age factor affecting recall, he is not as definite as to the age-level that this factor ceases to affect memory span performance. However, the results mentioned by Blankenship do not place the maximal development of memory capacity prior to the age of twelve. Therefore, in the present study, since the oldest subjects were twelve years of age, it is expected that age would be a factor. Age alone however, was not the only factor investigated. The effect of increased grade level was investigated along with the increased age of the subjects.

2.) The sex of the individual.

This factor seems to have an unclear effect on memory span as Blankenship states:

> Thus we can reach no conclusion as to the role of sex in memory span. All we can do at this time is to note that sex may be a factor.
>
> (Blankenship, 1938, p.15)

In the present study each group of subjects was divided into an equal number of males and females in order to investigate the possibility of differences in the development of memory. The possibility of a difference between the performance of males and females was investigated not only within each group but also across all groups as well in order to examine the possible differential development of memory processes between males and females.

Blankenship mentions two other factors, the race of the subjects, and their permanent pathological condition, which were irrelevant to the present study.

The factors, listed by Blankenship (1938) have not always been considered in the design of memory studies following the publication of his article. Although there may be other influences involved, the factors emphasized by Blankenship provided an excellent design to follow.

CHAPTER IV

METHODOLOGY

The purpose of this chapter is to describe the method and procedure used in the present study to enable later replication of the results. The actual stimuli used in the study are reproduced in Appendix A.

Subjects. Two hundred and forty elementary school subjects participated in the study. Ten males and ten females for each age-grade combination were randomly selected and tested. Each grade was divided into two age levels. (For example, the Grade Two subjects were divided into seven and eight year old age groups and the Grade Three subjects were divided into eight and nine year old age groups). The subjects were drawn from two urban elementary schools in Edmonton and one suburban elementary school in Sherwood Park.

Apparatus. Polymetric Company Tachistoscope Model V-0959T (234 South Eight Street, Reading, Pennsylvania, U.S.A.) was used to present the visual stimulus cards. The visual stimulus cards were eighteen 3 by 5 inch plastic covered white cards. One card with twelve digits, eight cards with six consonant letters and nine cards with twelve consonant letters. The strings of consonants were generated by placing one Scrabble piece representing each consonant in a bag

and drawing them out one by one. Letters were not replaced after the draw until all the letters had been drawn. Repetition of letters were therefore impossible. Upon completion, all sequences were scanned for alphabetical or meaningful sequences such as TV or NHL. All letters were spaced so that the distance from the first to the last letter on the card was exactly three inches. Cards with twelve letters or twelve numbers on them had a 1/4 inch space between the items. The cards with six items on them had a 1/2 inch space between the items. All letters were centered with a one inch border on each side and a 1-29/32 inch margin on the top and bottom of these cards. The consonants and numbers were 1/4 by 3/16 inch in size and were chosen from a Tetrite 4 printing set. The pre- and post-exposure field was a plastic covered white card.

Procedure

When the subject entered the testing room he was asked to sit on a chair placed in front of the tachistoscope. The subject was asked the grade level they were in and how they enjoyed school. Some informal conversation was always engaged in with the subject to allow time for some of the strangeness of the experimentors and the situation to dissipate before testing started. The subject's name, grade, age, birth date, testing date, and sex were recorded on the data sheet. Two experimentors were always in attendance, one to record the biographical and response data, the other to

give the instructions and to administer the tasks. The order of testing followed a standard procedure which paralleled the hypothesized developmental order of Iconic Memory, and then Immediate Memory. This order of presenting the tasks was the most efficient as each task introduced the task that followed, which gave the testing situation a natural progression from task to task rather than jumping from one task to another.

The procedure and instructions will be presented under the appropriate sub-headings which will name the factor that was being investigated at that time.

Iconic Memory. The subject was seated on a chair in front of the tachistoscope when the following instructions were given:

> "I am going to flash something very quickly on the white screen at the back of this box (referring to the tachistoscope). I am not going to tell you what I will flash. I want you to tell me what you see."

At this time the subject was positioned with their face fitting snugly into the face guard on the tachistoscope in order to keep out extraneous light.

> "I want you to keep your face in this head guard as tightly as possible. I want you to look at the screen at the back. Just before I flash the things on the screen I will say 'READY', then I will flash them. Do not worry if you cannot see them right away, they are flashed so quickly that most people may not be able to see them right away. All right? 'READY'"

At this point the first exposure of stimulus items was given at the 200 millisecond exposure level. Two exposures were given, one of letters and one of numbers. Whether the numbers or letters were presented first depended

upon the order given to the preceding subject. If the preceding subject was given the letters first, the following subject was exposed to the numbers first and so on, to avoid a bias towards which stimuli would be recognized more quickly than the other. If the subject did not recognize the items presented to them, alternate trials of letters and numbers were presented at each 100 millisecond increment level until both sets of stimuli were recognized. Each unsuccessful exposure level was marked on the data sheet as an 'x', the successful trial was marked with a check-mark. The instructions attempted to reassure those subjects who would not immediate recognize the stimuli flashed and also attempted to ensure attention at the proper time by the use of a cue before the exposure. The subject was also praised for their performance in the following manner:

> "You did very well on that part. You see that was not so hard was it?"

The exposure level at which the subject recognized letters as letters was used as the exposure level for the six trials presented in the Iconic Memory tasks. The subject was instructed:

> "Now, this time I am going to flash more letters on the screen. They will flash just as quickly as they did before but this time I want you to tell me as many of the letters you saw as you can. I will say 'READY' and then I will flash the letters. Remember, as soon as the letters flash tell me as many of the letters you saw as you can. All right? 'READY'."

The letters were in groupings of 6 and 12 letters per card, with three presentations of the six item displays, and three presentations of the twelve item displays. The

order of presentation was either: 6,12,12,6,6,12 or 12,6,6,12,12,6 depending on the order used for the previous subject. The order used alternated from subject to subject in order to randomize out a recall bias due to seeing a 6 item versus a 12 item display first. After each exposure the letters recalled were recorded as well as the card number and the order of presentation. Those subjects who recalled the entire or the most part of the alphabet were cautioned to recall only those letters that they actually saw. A new stimulus card was then presented as the first trial. If the subject persisted in randomly recalling strings of letters with no relationship to the stimulus items, they were at this point thanked for their participation in the study, returned to their classroom, and deleted from the study. With the subjects continuing in the study, testing continued until a total of three 6 item and three 12 item displays were responded to. If a subject responded that they could not see the items, the particular card was set aside and shown again at the end of the original exposure order. Any card exposed more than once was noted on the data sheet. Since more subjects were tested than required for this study, those subjects having no recall and those requiring more than one extra exposure of stimulus cards were discarded from the study. After each exposure the subject's recall was responded to by the experimentor in the following manner:

"That's very good, try this one."

At no time during testing were the subjects told whether the 6 or 12 item display was going to be shown.

Immediate Memory. Upon completion of the six trials for Iconic Memory performance the subject was instructed:

> "You did very well on that part, now this time I am going to show you more letters but this time you will have a much longer time to look at them. That will make it easier for you to remember them won't it? (pause for the subject's response) This time though, I want you to remember the letters from left to right in the same order that you see them (at this point the subject was shown the letter stimulus card used for establishing the Recognition Threshold and shown with the aid of this card what was required). Remember, when the letters disappear you tell me as many of the letters that you saw as you can, but please remember them in order. Do not repeat the letters out loud while they are on the screen, but as soon as they disappear tell me, in the correct order, as many of the letters as you can remember."

The order of presentation was the opposite of the order used in testing Iconic Memory performance, either 12,6,6,12,12,6 or 6,12,12,6,6,12. The first pair of stimulus cards were exposed for 3 seconds, the second pair for 6 seconds, and the final pair for 9 seconds. After the last 3 and 6 second exposure and prior to the first exposure at the next time level the subject was instructed:

> "This time you will have a longer time to look at the letters. Remember to tell me the letters in the order they were on the screen."

After each attempt by the subject to recall the items they were told:

> "That's very good, now try this one."

Those subjects who persisted in recalling letters randomly or who could not recall any letters after any one of the exposures of stimulus items were deleted from the study.

When testing was completed, if the subject wished to examine the tachistoscope, they were shown how it worked. They were not given any information which could affect the performance of another subject who they might talk to. In general, the subjects who were the first from the classroom were slightly apprehensive and an attempt was made to make them feel comfortable. The younger subjects in particular were instructed after the testing was completed:

> "You did very well on that. You see it was not hard at all, in fact it was rather fun, wasn't it? (pause for subject's response). Be sure to tell the rest of your class how much fun it was, but don't tell them what we did because we want to surprise them."

Some subjects with partial blindness, a recent illness, or subjects who had engaged in a vigorous physical exercise just prior to testing were deleted from the study. The testing session was designed to last approximately five minutes in order to ensure a high level of subject attention and performance during testing. The actual time taken varied from five to seven minutes, depending on the age of the subject. The younger subjects usually required additional repetitions of the instructions.

Analysis

A one-way analysis of variance with a Newman-Keuls comparison between ordered means subroutine was used to examine the between-group differences. A three-way analysis of variance was used to examine the effects within and between groups on the variables "stimulus density", "exposure level", and "sex" of subject. All programs used were supplied by the Division of Educational Research, University of Alberta, Edmonton, Canada.

Postulates

To investigate age-grade differences on recall for two different stimulus densities and varying exposure times in two stages of the memory model, namely, Iconic and Immediate Memory. Further, for those subjects whose Iconic capacity is functionally more mature (as measured by a consistently greater recall on the 12 letter condition as compared to the 6 letter condition) it is postulated that their recall on Immediate Memory tasks will be consistently greater than those subjects whose Iconic Memory is functionally immature (as measured by a consistently greater recall on the 6 letter condition as compared to the 12 letter condition).

Hypotheses

To investigate these postulates the following

hypotheses were developed.

Iconic Memory

1. There will be no significant difference in mean recall for 6 and 12 letters between all age-grade groups.

Immediate Memory

1. There will be no significant differences in mean recall for either 6 or 12 letters at the three-second exposure level between all age-grade groups.

2. There will be no significant difference in mean recall for either 6 or 12 letters at the six-second exposure level between all age-grade groups.

3. There will be no significant difference in mean recall for either 6 or 12 letters at the nine-second exposure level between all age-grade groups.

4. There will be no significant difference in mean recall in the 6 letter condition for the three-, six-, and nine-second exposure levels within each age-grade group.

5. There will be no significant difference in mean recall in the 12 letter condition for the three-, six-, and nine-second exposure levels within each age-grade group.

CHAPTER V

RESULTS

The results of 240 elementary school subjects were obtained for all Iconic Memory and Immediate Memory variables. Table 1 gives a comprehensive description of the sample used in the present study. Table 2 lists all the variables tested in the present study. Table 3 contains a summary of the results of the one-way analysis of variance analysis. Tables 4 to 11 present the results of the Newman-Keuls comparison of ordered means for each variable used in the study.

Table 1. Table 1 lists the numbers, descriptions, average ages, sizes, and identification abbreviations for all groups included in the sample. Each grade level included two age groups whose average age difference for the total sample was 7.26 months. Each age level, with the exception of the six and twelve year olds, occurred in two grade groups. The average age difference between subjects of the same age but different grade level was 4.26 months. The subjects in the higher grade tended to be slightly older than their age-mates in the lower grade. In each group an equal number of male and female subjects were tested. In order to expediate the reporting and discussion of the results the group abbreviations will be used rather than the complete group description. The first number, or the Roman numeral, indicates the

grade level of the subject, the second number or the Arabic number, indicates the age level of the subject.

Insert Table 1 about here

Table 2. This table lists all the variables by number, description, and abbreviation. The order presented in the table represents the actual order of testing. Two Iconic Memory and six Immediate Memory measures were used. The abbreviations given for the variables will be used mainly on the tables to be presented.

For Iconic Memory (IcM) the number of stimulus items presented is designated by the number 6 for the six letter displays and the number 12 for the twelve letter displays. For Immediate Memory (IM) the first number refers to the time exposure duration in seconds, the second number refers to the stimulus density, either six or twelve items.

Insert Table 2 about here

Between Group Analysis. The results of the one-way analysis of variance is presented in Table 3. Only the pertinent findings and general trends are discussed under the headings of Iconic Memory and Immediate Memory.

Table 1

Group Names, Average Ages,* Abbreviations for All Groups in Memory Sample

Number of Groups	Groups by Grade	Groups by Age	Average Age Years	Average Age Months	Group Abbreviation	Group Size Males	Group Size Females	Group Size Total
1.	Grade One	- Six Year Olds	6	6.87	I-6	10	10	20
2.	Grade One	- Seven Year Olds	7	5.42	I-7	10	10	20
3.	Grade Two	- Seven Year Olds	7	7.36	II-7	10	10	20
4.	Grade Two	- Eight Year Olds	8	3.00	II-8	10	10	20
5.	Grade Three	- Eight Year Olds	8	8.45	III-8	10	10	20
6.	Grade Three	- Nine Year Olds	9	3.75	III-9	10	10	20
7.	Grade Four	- Nine Year Olds	9	8.09	IV-9	10	10	20
8.	Grade Four	- Ten Year Olds	10	2.70	IV-10	10	10	20
9.	Grade Five	- Ten Year Olds	10	6.59	V-10	10	10	20
10.	Grade Five	- Eleven Year Olds	11	2.90	V-11	10	10	20
11.	Grade Six	- Eleven Year Olds	11	8.64	VI-11	10	10	20
12.	Grade Six	- Twelve Year Olds	12	2.90	VI-12	10	10	20

*Ages as of date tested

Table 2

Memory Variables by Number, Description, and Abbreviation

Variable Number	Variable Name	Variable Abbreviation
1	Iconic Memory Mean Recall for Six Items, Three Trials	IcM/6
2	Iconic Memory Mean Recall for Twelve Items, Three Trials	IcM/12
3	Immediate Memory Serial Recall of Three Seconds, Six Items	IM (3-6)
4	Immediate Memory Serial Recall at Three Seconds, Twelve Items	IM (3-12)
5	Immediate Memory Serial Recall at Six Seconds, Six Items	IM (6-6)
6	Immediate Memory Serial Recall at Six Seconds, Twelve Items	IM (6-12)
7	Immediate Memory Serial Recall at Nine Seconds, Six Items	IM (9-6)
8	Immediate Memory Serial Recall at Nine Seconds, Twelve Items	IM (9-12)

Table 3. Table 3 shows the means and F-ratios for all groups over all variables. All the F-ratios are significant at the .01 level or greater. Tables 4 to 11 present the results of the Newman-Keuls comparison of ordered means for each variable used in the study.

Insert Table 3 about here

Iconic Memory. (IcM_6, IcM_{12}) The number of letters correctly recalled tended to increase as age and grade increased. Tables 4 and 5 show the mean recall for the six and twelve letter displays respectively for each age-grade group with the stimulus exposure at each individual's specific letter recognition exposure level.

Insert Table 4 about here

In Table 4 for the six letter displays (IcM_6), I-6 subjects had significantly lower recall than all other groups. This finding reveals a significant age difference between I-7 subjects and I-6 subjects. However, III-8 subjects show significantly greater recall than II-8 subjects which could demonstrate the influence of education on this age group. It appears that initially recall in Iconic Memory is affected by the maturation level, then later by the grade or experience level of the subjects.

Insert Table 5 about here

Table 3

One-Way Analysis of Variance With Group Means and F-Ratios

Variable	Groups											
	I-6	I-7	II-7	II-8	III-8	III-9	IV-9	IV-10	V-10	V-11	VI-11	VI-12	F-Ratio
Ic.M./6	1.2015	1.6665	2.1830	2.0340	2.7325	2.5505	2.6655	2.6670	2.2665	2.9325	2.6830	2.9995	10.87
Ic.M./12	1.2835	1.9670	2.0500	1.9340	2.6995	3.0505	2.9500	2.7320	2.6995	3.1495	2.8825	3.4160	10.74
IM (3/6)	2.7000	3.3000	3.7000	2.8000	4.3000	4.7000	4.4500	3.8500	4.3500	4.4000	4.8500	4.8000	8.84
IM (3/12)	2.9000	2.9000	3.2500	2.9500	3.7000	4.0000	4.1000	3.9000	4.1500	3.9500	4.4500	4.3000	4.28
IM (6/6)	3.0000	2.8500	3.6500	3.4000	4.8500	4.9500	4.6000	4.2500	4.8000	4.9000	5.2500	5.2000	10.45
IM (6/12)	2.3500	2.2500	2.6000	2.1500	3.2500	4.1000	3.9500	3.3000	3.3000	4.2000	4.4500	4.8500	10.80
IM (9/6)	3.2500	3.1500	3.8000	3.2000	4.6000	5.2000	5.0500	4.5500	5.4500	5.0500	5.4000	5.0500	13.83
IM (9/12)	2.6500	2.3000	3.0500	2.5000	3.8000	4.5000	4.8500	3.7500	4.1500	4.0000	5.1500	5.3000	13.70

An F-ratio of 3.66 is significant at the .01 level.

Table 4

Newman-Keuls Comparison of Ordered Means of Iconic Memory Recall for Six Letters

Groups	Mean	Groups: VI-12	V-11	III-8	VI-11	IV-10	IV-9	III-9	V-10	II-7	II-8	I-7	I-6
VI-12	2.999								*	*	*	*	*
V-11	2.932								*		*	*	*
III-8	2.732										*	*	*
VI-11	2.683										*	*	*
IV-10	2.667										*	*	*
IV-9	2.665										*	*	*
III-9	2.550											*	*
V-10	2.266											*	*
II-7	2.183												*
II-8	2.034												*
I-7	1.666												*
I-6	1.201												

*indicates $p < .05$

Table 5

Newman-Keuls Comparison of Ordered Means of Iconic Memory Recall for Twelve Letters

Groups	Mean	Groups: VI-12	V-11	III-9	IV-9	VI-11	IV-10	III-8	V-10	II-7	I-7	II-8	I-6
VI-12	3.416									*	*	*	*
V-11	3.149									*	*	*	*
III-9	3.050									*	*	*	*
IV-9	2.950									*	*	*	*
VI-11	2.882									*	*	*	*
IV-10	2.732									*	*	*	*
III-8	2.699									*	*	*	*
V-10	2.699									*	*	*	*
II-7	2.050												*
I-7	1.967												*
II-8	1.934												*
I-6	1.283												

*indicates $p < .05$

In Table 5 for the twelve letter displays (IcM_{12}), I-6 subjects had significantly lower recall than all other groups. Further, all the older subjects (III-8 to VI-12) showed significantly greater recall for the twelve letter displays than the younger subjects (I-6 to II-8). The trend for the younger subjects (I-6 to II-8) to recall fewer letters than the older subjects (III-8 to VI-12) is noticeable in the six letter condition, but is only statistically significant for the twelve letter condition.

This separation into younger and older subjects also occurs on the basis of a shift from the lack of a definite trend in the younger subjects to a consistent trend in the older subjects for more letters to be recalled in the twelve letter condition than in the six letter condition (See Figure 2). In both the six and twelve letter conditions, the oldest subjects (VI-12) show the highest recall.

Insert Figure 2 about here

Immediate Memory. (IM_{3-6}, IM_{3-12}, IM_{6-6}, IM_{6-12}, IM_{9-6}, IM_{9-12}) Tables 6 and 7 show the mean recall of all groups for the six and twelve letter displays respectively at the three second exposure level (IM_{3-6} and IM_{3-12}).

Insert Table 6 about here

In Table 6 for the six letter displays, all older subjects (III-8 to VI-12) have significantly greater recall

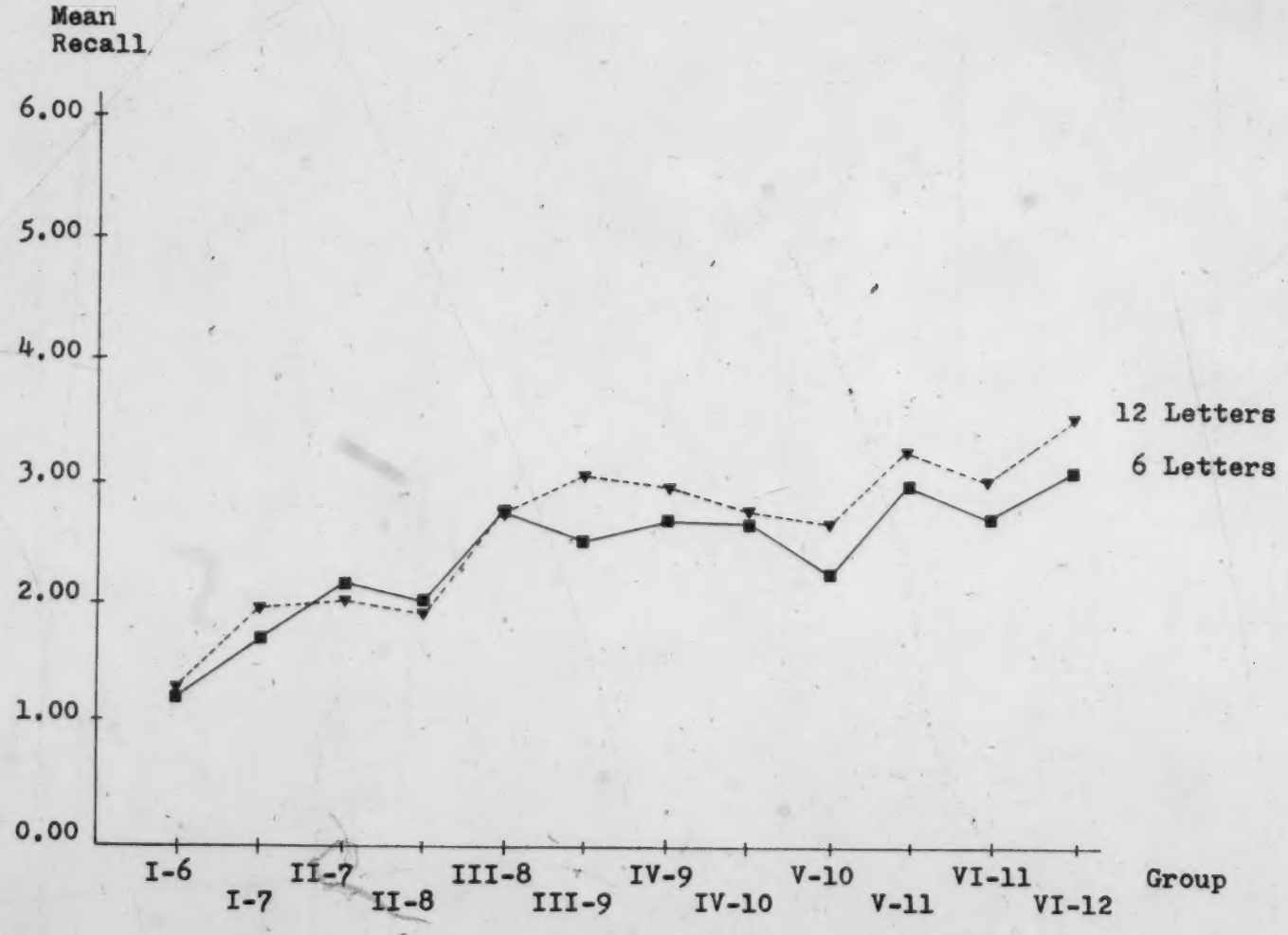

FIGURE 2

ICONIC MEMORY CAPACITY FOR SIX AND TWELVE LETTERS
FOR ALL GROUPS

Table 6

Newman-Keuls Comparison of Ordered Means of Immediate Memory Recall for Six Letters At the Three Second Exposure Level

Groups	Mean	Groups: VI-11	VI-12	III-9	IV-9	V-11	V-10	III-8	IV-10	II-7	I-7	I-6	II-8
VI-11	4.85									*	*	*	*
VI-12	4.80									*	*	*	
III-9	4.70									*	*	*	
IV-9	4.45									*	*	*	
V-11	4.40									*	*	*	
V-10	4.35									*	*	*	
III-8	4.30									*	*	*	
IV-10	3.85										*	*	
II-7	3.70												
I-7	3.30												
I-6	2.85												
II-8	2.80												

*indicates $p < .05$

Table 7

Newman-Keuls Comparison of Ordered Means of Immediate Memory Recall for Twelve Letters at the Three Second Exposure Level

Groups	Mean	Groups: VI-11	VI-12	V-10	IV-9	III-9	V-11	IV-10	III-8	II-7	II-8	I-7	I-6
VI-11	4.45									*	*	*	*
VI-12	4.30									*	*	*	
V-10	4.15									*	*	*	
IV-9	4.10									*	*	*	
III-9	4.00												
V-11	3.95												
IV-10	3.90												
III-8	3.70												
II-7	3.25												
II-8	2.95												
I-7	2.90												
I-6	2.90												

*indicates $p < .05$

than subjects in I-6 and II-8 for the six letter display. With the exception of IV-10 subjects, all older subjects (III-8 to VI-12) are also significantly higher than I-7 subjects for the six letter display. For both the six and twelve letter displays only the VI-11 subjects had significantly greater recall than all younger subjects (I-6 to II-8).

Insert Table 7 about here

In Table 7 for the twelve letter displays, only the IV-9, V-10, VI-11, and VI-12 subjects have significantly greater recall for the twelve letter display than the subjects in groups I-6, I-7, and II-8. Although there is a trend for more letters to be recalled for the six letter condition (see Figure 3), none of these differences are statistically significant at the three second exposure level.

Insert Figure 3 about here

Tables 8 and 9 show the mean recall of all groups for the six and twelve letter displays respectively at the six second exposure level (IM_{6-6} and IM_{6-12}).

Insert Table 8 about here

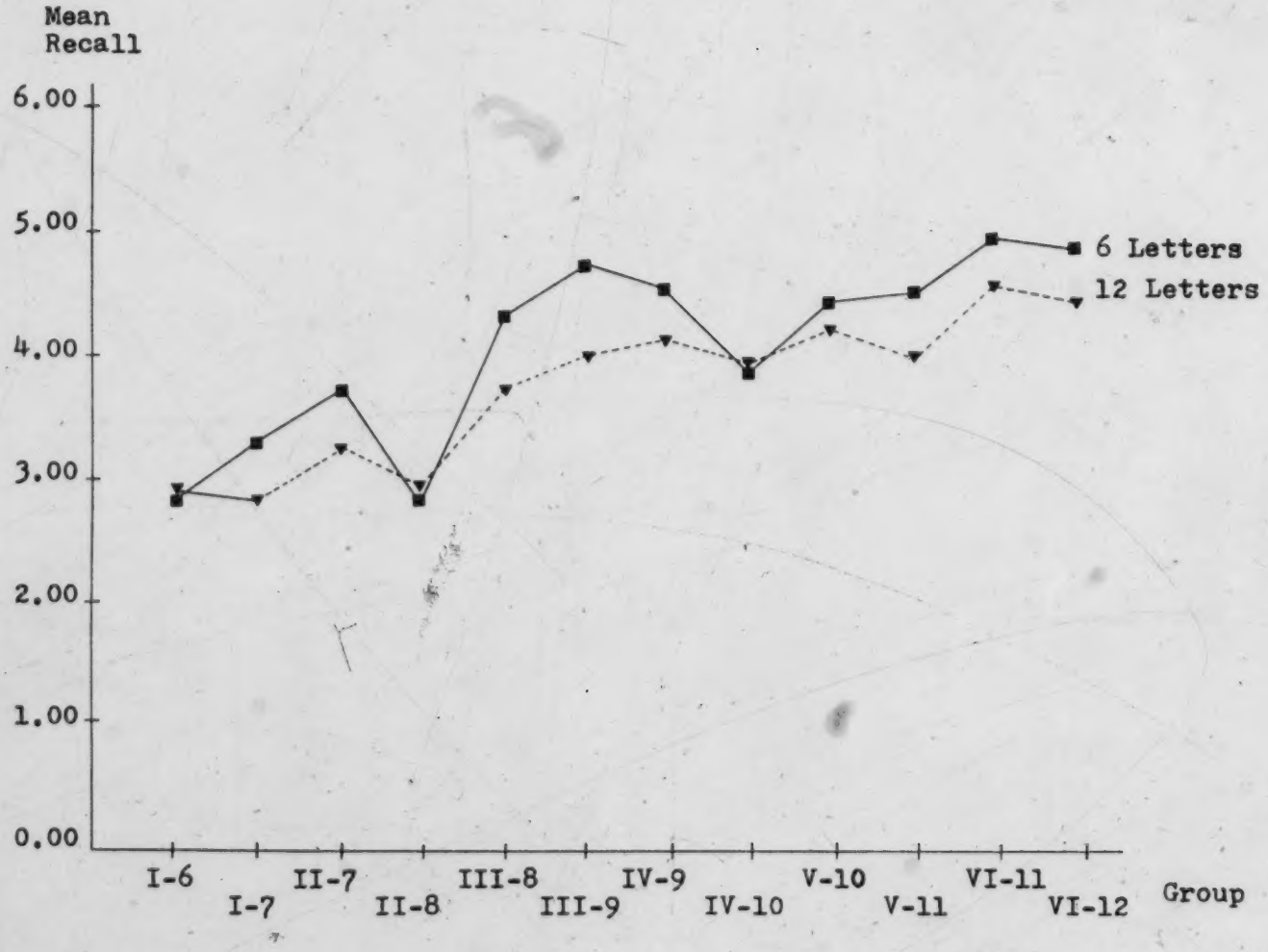

FIGURE 3

IMMEDIATE MEMORY RECALL FOR THE THREE SECOND EXPOSURE LEVEL

Table 8

Newman-Keuls Comparison of Ordered Means of Immediate Memory Recall for Six Letters At the Six Second Exposure Level

Groups	Mean	Groups: VI-11	VI-12	III-9	V-11	III-8	V-10	IV-9	IV-10	II-7	II-8	I-6	I-7
VI-11	5.25									*	*	*	*
VI-12	5.20									*	*	*	*
III-9	4.95									*	*	*	*
V-11	4.90									*	*	*	*
III-8	4.85									*	*	*	*
V-10	4.80									*	*	*	*
IV-9	4.60									*	*	*	*
IV-10	4.25										*	*	*
II-7	3.65												
II-8	3.40												
I-6	3.00												
I-7	2.85												

*indicates $p < .05$

Table 9

Newman-Keuls Comparison of Ordered Means of Immediate Memory Recall for Twelve Letters at the Six Second Exposure Level

Groups	Mean	Groups: VI-12	VI-11	V-11	III-9	IV-9	V-10	IV-10	III-8	II-7	I-6	I-7	II-8
VI-12	4.85					*	*	*	*	*	*	*	*
VI-11	4.45					*	*	*	*	*	*	*	*
V-11	4.20									*	*	*	*
III-9	4.10									*	*	*	*
IV-9	3.95									*	*	*	*
V-10	3.30												*
IV-10	3.30												*
III-8	3.25												*
II-7	2.60												
I-6	2.35												
I-7	2.25												
II-8	2.15												

*indicates $p < .05$

With the exception of IV-10 subjects, all the older groups (III-8 to VI-12) have significantly greater recall for the six letter display than all the younger subjects (I-6 to II-8).

Insert Table 9 about here

As can be seen in Table 9, for the twelve letter display, with the exception of groups III-8, IV-10 and V-10 all older groups had significantly greater recall than all younger subjects (I-6 to II-8). In addition, both age groups in grade six (VI-11 and VI-12) have significantly greater recall than the subjects in groups III-8, IV-10 and V-10. It appears that this six second exposure time provides for better distinctions among the older subjects. That is, the results for the six second exposure level clearly identify the fact that the older the subject, the significantly greater the recall, especially for twelve letters. (See Figure 4)

Insert Figure 4 about here

Tables 10 and 11 show the mean recall for all groups for six and twelve letter displays respectively at the nine second exposure level (IM_{9-6} and IM_{9-12}). This nine second exposure level provides the most complete distinction between the younger subjects (I-6 to II-8) and

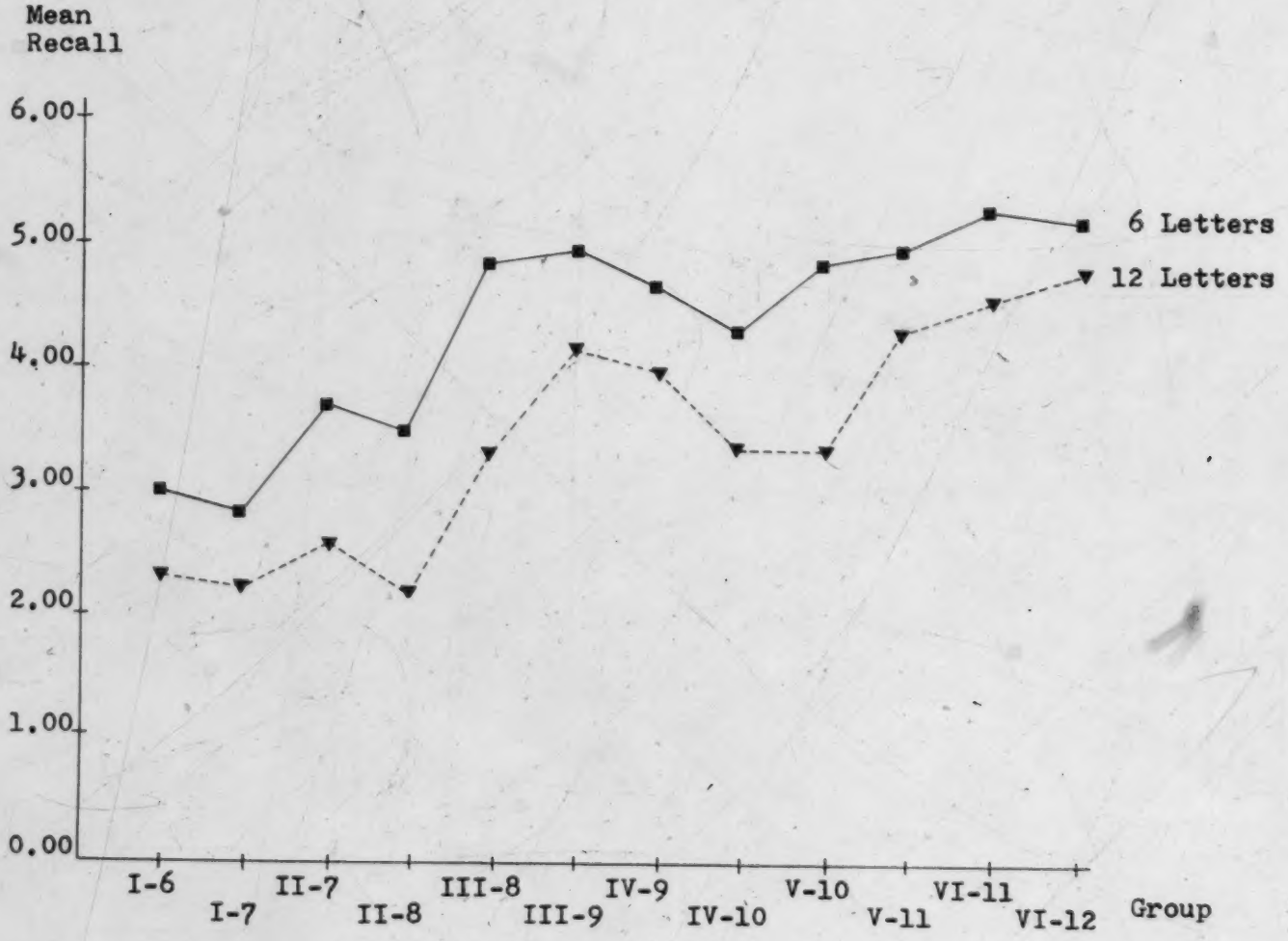

FIGURE 4

IMMEDIATE MEMORY RECALL FOR THE SIX SECOND EXPOSURE LEVEL

the older subjects (III-8 to VI-12) for both the six and twelve letter display. (See Figure 5)

Insert Figure 5 about here

For the six letter display, all older subjects (III-8 to VI-12) have significantly greater recall than all younger subjects (I-6 to II-8). (See Table 10)

Insert Table 10 about here

From the results in Table 11, one can see that for the twelve letter display, with the exception of groups III-8, IV-10 and V-11, all older subjects have significantly greater recall for twelve letters than all younger subjects (I-6 to II-8).

Insert Table 11 about here

As with the six second exposure level for the twelve letter display, the grade six subjects (VI-11 and VI-12) had significantly greater recall than other older groups, specifically groups III-8, IV-10 and V-11. In both the six and nine second exposure level, VI-12 subjects were consistently superior in recall for the twelve letter display than all other groups. Further, the trend noted at the three second exposure level for more of the six letter display to be recalled than the twelve letter display, was dramatized at the six second exposure level. (see Figure 6)

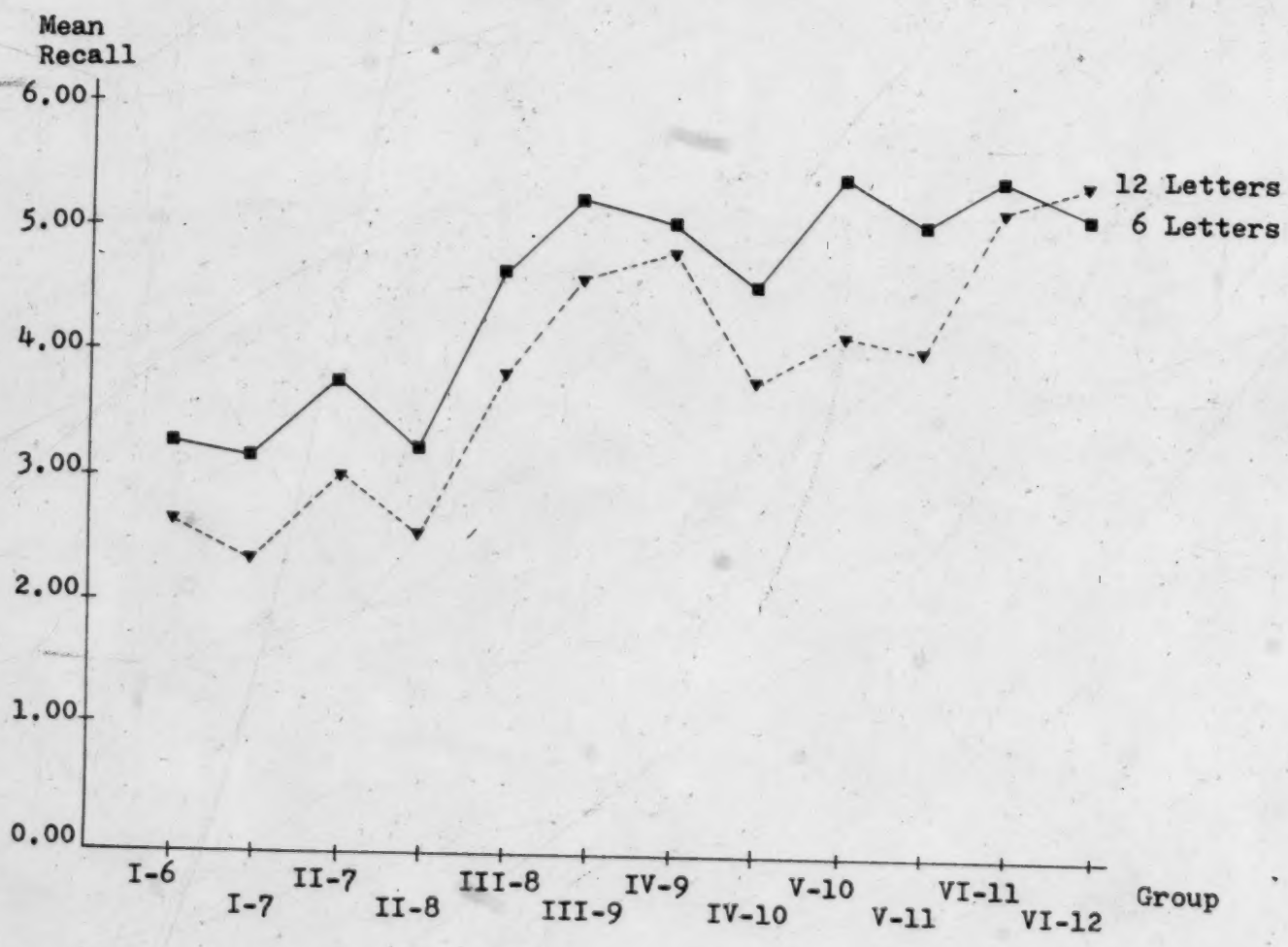

FIGURE 5

IMMEDIATE MEMORY RECALL FOR THE NINE SECOND EXPOSURE LEVEL

Table 10

Newman-Keuls Comparison of Ordered Means of Immediate Memory Recall for Six Letters at the Nine Second Exposure Level

Groups	Mean	Groups: V-10	VI-11	III-9	VI-12	V-11	IV-9	III-8	IV-10	II-7	I-6	II-8	I-7
V-10	5.45										*	*	*
VI-11	5.40										*	*	*
III-9	5.20										*	*	*
VI-12	5.05										*	*	*
V-11	5.05										*	*	*
IV-9	5.05										*	*	*
III-8	4.60										*	*	*
IV-10	4.55										*	*	*
II-7	3.80												
I-6	3.25												
II-8	3.20												
I-7	3.15												

*indicates $p < .05$

Table 11

Newman-Keuls Comparison of Ordered Means of Immediate Memory Recall for Twelve Letters at the Nine Second Exposure Level

Groups	Mean	Groups: VI-12	VI-11	IV-9	III-9	V-10	V-11	III-8	IV-10	II-7	I-6	II-8	I-7
VI-12	5.35					*	*	*	*	*	*	*	*
VI-11	5.15					*	*	*	*	*	*	*	*
IV-9	4.85								*	*	*	*	*
III-9	4.50								*	*	*	*	*
V-10	4.15								*	*	*	*	*
V-11	4.00									*	*	*	*
III-8	3.80									*	*	*	*
IV-10	3.75									*	*	*	*
II-7	3.05												
I-6	2.65												
II-8	2.50												
I-7	2.30												

*indicates $p < .05$

Insert Figure 6 about here

Figure 6 shows the effect of increasing exposure time on mean recall for all groups for the six letter displays. The effect of increased exposure time on recall in the younger groups (I-6 to II-8) and also III-8 subjects is somewhat erratic. However, groups III-9 to VI-12 show a consistent trend for the recall for the six letter display to increase as exposure time increases. Very few of the differences within groups for recall at different exposure time levels are statistically significant.

Insert Figure 7 about here

Figure 7 shows the effect of increasing exposure time on mean recall for all groups for the twelve letter displays. The most consistent general trend appears to be that the six second exposure level produces the poorest recall. For the younger subjects (I-6 to II-8) the three second exposure produces the highest recall, whereas with the older subjects (III-8 to VI-12) the nine second exposure most often produces the highest recall. It should be noted that only VI-12 subjects display a consistent increase in recall as a function of increased exposure level. Very few of the remaining differences in recall, as a function of exposure time, are statistically significant.

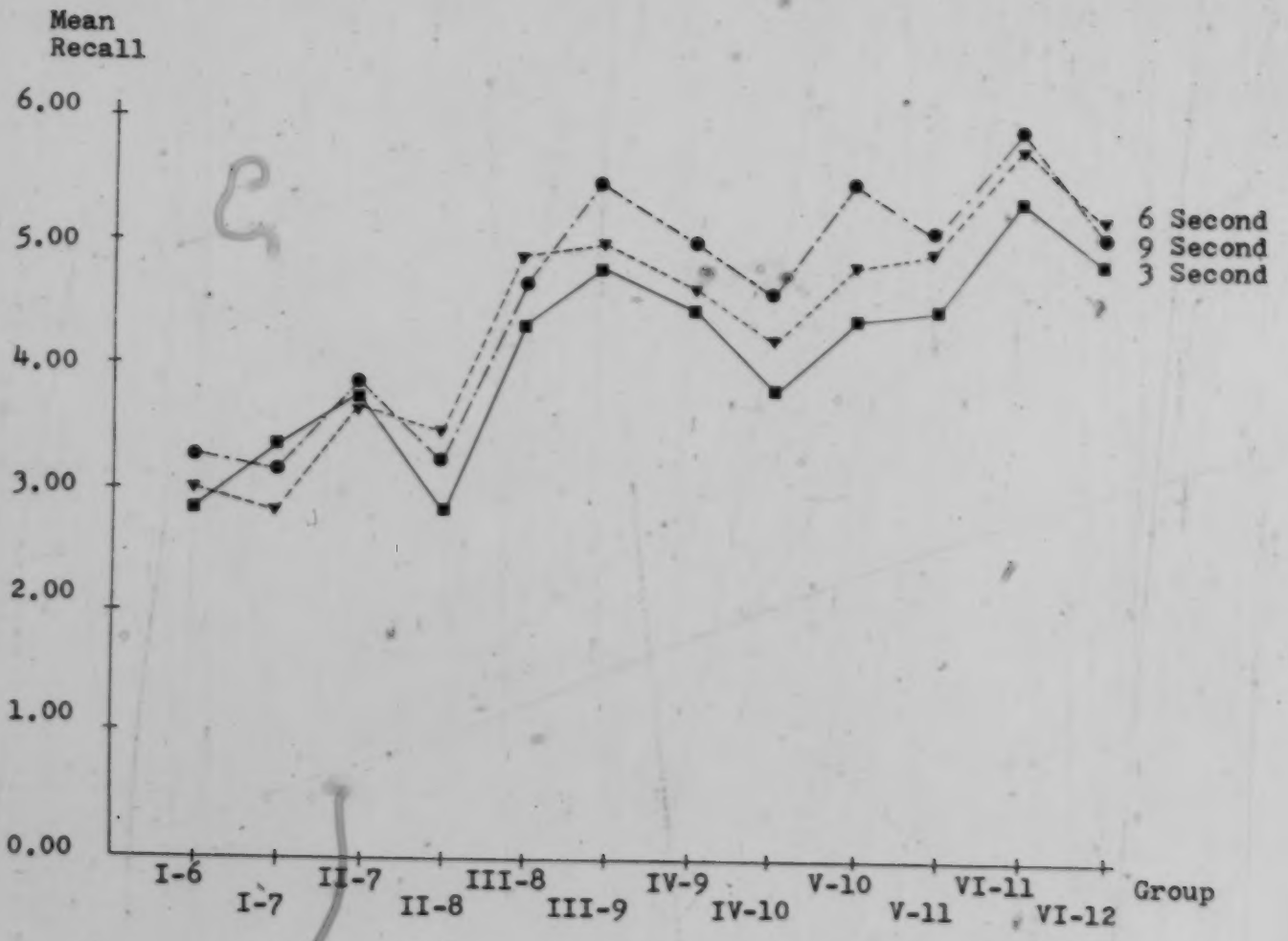

FIGURE 6

IMMEDIATE MEMORY RECALL FOR THE SIX LETTER STIMULUS DENSITY OVER ALL EXPOSURE TIMES

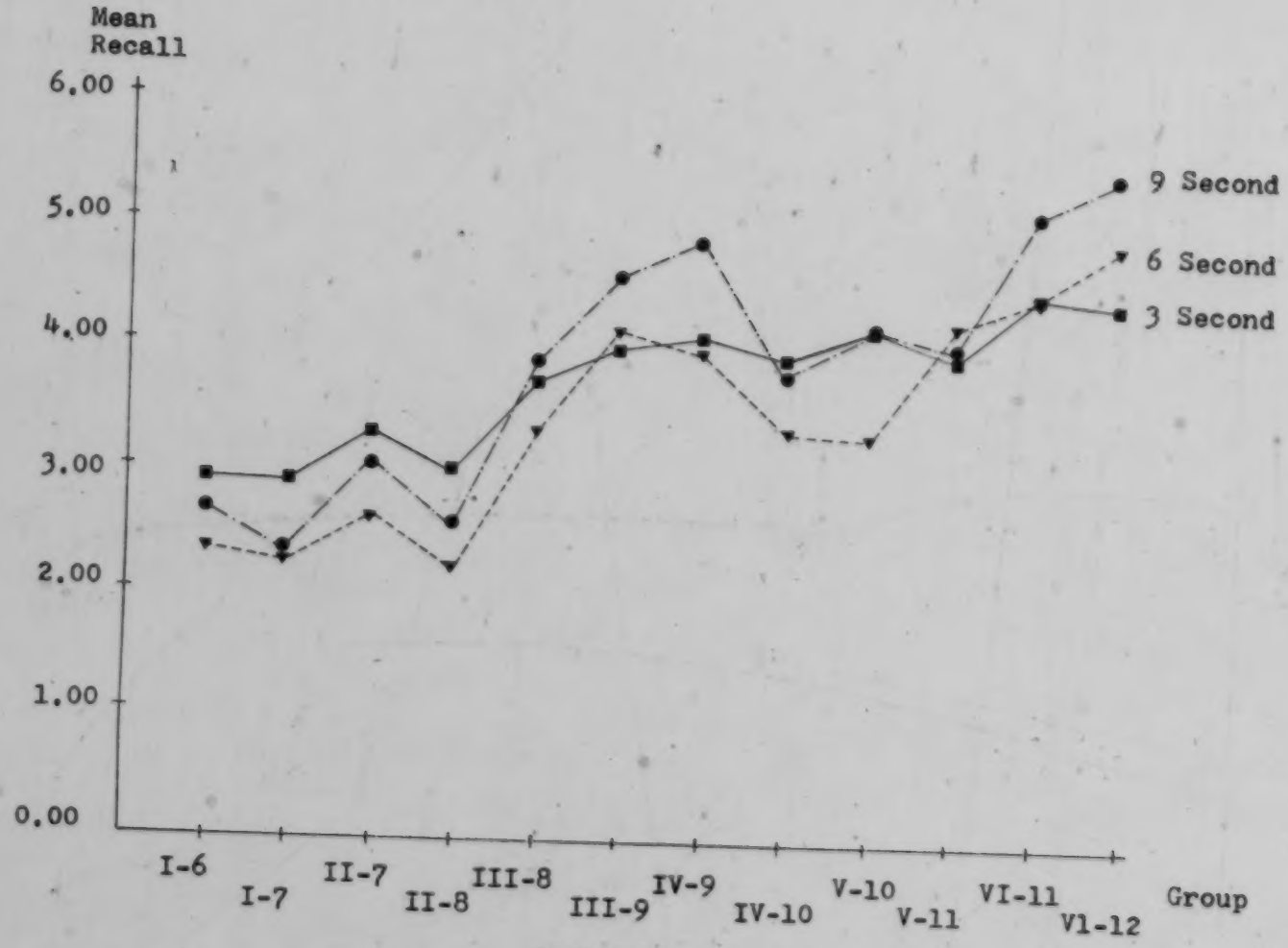

FIGURE 7

IMMEDIATE MEMORY RECALL FOR THE TWELVE LETTER STIMULUS DENSITY OVER ALL EXPOSURE TIMES

Three-Way Analysis of Variance. The three-way analysis of variance used a 2 x 3 x 2 design with repeated measures on two variables to examine performance on Immediate Memory tasks. The repeated measures variables were stimulus density and exposure level. Table 12 contains a summary of the analysis.

Insert Table 12 about here

As can be seen from Table 12, the sex of the subject (variable A) was not a relevant factor in recall on Immediate Memory tasks ($p < 0.337$). The effect of varying stimulus density (variable B) was identified as a relevant factor in recall on Immediate Memory tasks ($p < 0.000$). This result indicates, in conjunction with an examination of Figures 3 to 5, that the subjects, in the present study, recalled significantly more of the six letter than the twelve letter displays across all exposure levels used. The effect of varying exposure times (variable C) was identified as a relevant factor in recall on Immediate Memory tasks ($p < 0.000$). This result is difficult to interpret specifically because of the apparent inconsistency amongst the subject groups of the effect of varying exposure levels. This inconsistency in effect is highlighted when one compares the F-ratios for stimulus density (107.95), which is a consistent factor in recall, and exposure levels (13.40) which appears to be an

Table 12

Summary of the Three-Way Analysis of Variance

Source	SS	DF	MS	F	P
Between Subjects	1517.000	239			
A*	5.8789062	1	5.8789062	0.93	0.337
Subjects Within Group	1511.1211	238	6.3492479		
Within Subjects	1560.6680	1200			
B**	139.37891	1	139.37891	107.95	0.000
A B	0.390625	1	0.39063	0.00	0.956
Bx Subjects Within Group	307.28516	238	1.29111		
C***	27.29297	2	13.64648	13.40	0.000
A C	0.50391	2	0.25195	0.25	0.781
Cx Subjects Within Group	484.87109	476	1.01864		
B C	21.07031	2	10.53516	8.68	0.000
A B C	2.43750	2	1.21875	1.00	0.367
B Cx Subjects Within Group	577.82422	476	1.21392		

*A = sex
**B = stimulus density
***C = exposure level

inconsistent factor in recall in terms of generalizing specific conclusions concerning exposure levels to all subjects.

The interactions observed between sex and stimulus density (AB $p < .956$) and sex and exposure levels (AC $p < .781$) indicate that the significant effects on recall observed for stimulus density and exposure level were not related to the sex of the subject. This result is further supported by the lack of a significant interaction between sex, stimulus density, and exposure level (ABC $p < .367$).

The significant interaction observed between stimulus density and exposure level (BC $p < 0.000$) indicates a combined effect on recall. It should be noted that the interaction F-ratio (8.68) is lower than either of the main effects and reference to Figures 6 and 7 suggests that this may be due to the differential effects of time on stimulus density over the subject groups.

Summary of Results

The results of the one-way analysis of variance demonstrated that the amount of information processed from Iconic Memory and the Immediate Memory span for high and low density stimulus items in elementary school subjects are developmental capacities and tend to increase in efficiency as age and grade increase. The most notable differences between groups occurred between the subjects in Grade Six and all subjects in Grades One and Two

observed in the Newman-Keuls analysis of ordered means.

The three-way analysis of variance demonstrated that exposure time, stimulus density, and the interaction of exposure time and stimulus density were significant factors affecting recall on Immediate Memory tasks. The sex of the subject was not a significant factor in the recall of letters in Immediate Memory tasks.

CHAPTER VI

DISCUSSION AND CONCLUSION

The primary objective of this research was to establish normative data on the performance of elementary school subjects on tasks measuring the amount of information processed in Iconic and Immediate Memory. This chapter discusses the results in relation to the objectives of this study under the headings of the hypotheses designed to test them.

Iconic Memory

This stage of the memory process was defined as the amount of information processed, or the Iconic Memory transfer capacity. The rationale for the use of the individual subject's recognition level of letters as the exposure level for examining Iconic Memory capacity was both theoretical and methodological. Brackbill (1967) states that the child's visual system cannot process information as efficiently as the adult, whereas Haith (1971) reports that children are not perceptually slower than adults. This paradox was emphasized by the disagreement on the effect of exposure time on Iconic Memory capacity between Mackworth (1962) and Sperling (1960) for adult subjects. In order to resolve this dilemma, and to control for the perceptual after-image factor mentioned by

Fechner (in James, 1890), it was determined to establish an exposure level for each subject which would constitute a functional 'glance'. This functional 'glance' was the exposure level at which the subject could first extract relevant information from the stimulus items presented.

Hypothesis 1 stated that there would be no significant difference in mean recall for 6 and 12 letters between all age-grade groups. The results of the one-way analysis of variance indicates a significant difference between groups in the mean recall of 6 and 12 letters. Therefore Hypothesis 1 is rejected. The differences between groups seems to be related to an increase in age and grade based on the results of the Newman-Keuls analysis. The significant difference between I-7 and I-6 subjects suggests a maturational effect on performance at this level. However, the significant difference observed between III-8 and II-8 subjects tends to suggest an educational effect on performance. The trend observed with the recall of 6 letters was for the I-6, I-7, II-7, and II-8 subjects to form a group of the lowest means for the recall of letters. All subjects in groups III-8 to VI-12 performed significantly better on mean recall for 12 letters than did I-6 to II-8 subjects. For the 6 and 12 letter mean recall all groups performed significantly better in mean recall than the I-6 subjects.

One of the most important findings was the trend for subjects in III-9 to VI-12 to consistently recall more of the 12 letter displays than of the 6 letter displays. This finding is emphasized by the trend for all age-grade groups III-8 and above to recall significantly more of the 12 letter displays than subjects in II-8 and below. It appears that this difference between the eight year old subjects in Grades Two and Three marks the emergence of a functionally effective Iconic Memory. This interpretation is further supported by the consistent trend for the older subjects (III-9 to VI-12) to recall more of the 12 letter than the 6 letter displays, as compared to the younger subjects (I-6 to III-8). If, as the results reported by Teichner and Sadler (1962) and Haith (1971) suggest, the positive relationship between recall and stimulus density is a major distinguishing feature in the comparison of the recall in Iconic Memory between those subjects with a functionally developed Iconic Memory and those lacking a developed Iconic Memory, it seems reasonable to conclude that the subjects in groups III-9 to VI-12 do demonstrate a functionally developed Iconic Memory while those subjects in groups I-6 to III-8 do not.

Immediate Memory

The development of this stage of the memory process was examined by the recall for high and low stimulus densities over three exposure times.

Hypotheses 1, 2, and 3 stated that there would be no significant differences in mean recall for either 6 or 12 letters at the three exposure levels used between all age-grade groups. The results of the one-way analysis of variance indicates the existence of significant differences in mean recall for both stimulus densities at the three, six, and nine second exposure levels. Therefore Hypotheses 1, 2, and 3 are rejected. The trend noticed in Iconic Memory for the I-6 to II-8 groups to clump together with the lowest recall performance is consistent with their performance on all Immediate Memory tasks. This distinction into older (III-8 to VI-12) subjects and younger (I-6 to II-8) subjects is most significantly demonstrated for the recall of 6 letters at the nine second exposure level. Although the I-7, II-7, and II-8 subjects demonstrated significantly greater recall than the I-6 subjects in Iconic Memory, no significant differences are found on any of the Immediate Memory tasks. This finding seems to indicate that until a functionally effective Iconic Memory is developed all groups are unable to effectively function on Immediate Memory tasks.

The results of the three-way analysis of variance indicate that the exposure level and stimulus density are significant factors in recall, but the sex of the subject was not. This supports the report by Blankenship (1938) that the rate of presentation of the stimulus is a significant factor in recall.

Hypotheses 4 and 5 stated that there would be no significant difference in mean recall in the 6 and 12 letter condition for the three, six and nine second exposure levels within each age-grade group. The results of the three-way analysis of variance indicates a significant interaction between stimulus density and exposure time. Therefore Hypotheses 4 and 5 are rejected. The effect of exposure time on recall for the six letter displays was to emphasize the significant distinction between the younger subjects (I-6 to II-8) and the older subjects (III-8 to VI-12). As the exposure time increased, the significant differences between the older and younger subjects increased until, at the nine second exposure level, the recall of all the older subjects (III-8 to VI-12) was significantly greater than the recall of all the younger subjects (I-6 to II-8). This finding agrees with Belmont and Butterfield (1971) and Dornbush and Basow (1970) that the younger subjects cannot store the information for effective recall. This conclusion is emphasized by the linear relationship between exposure time and the recall of the six letter displays demonstrated by the III-9 to VI-12 groups. The I-6 to III-8 groups do not demonstrate this consistent trend for recall to increase as exposure time increases. The interpretation given this finding is that the older subjects have developed the ability to store the information and the increases in exposure time also permits the increased use of storage

and coding strategies. It is of interest to note that although the III-8 group had significantly greater recall than the younger groups, for all exposure times, it did not demonstrate the linearly related increases in recall as exposure time increased. The III-8 group may be demonstrating the level at which Iconic Memory is in the final stages of development and a precursor to the development of adequate storage and coding strategies.

The effect of exposure time on the recall for the twelve letter displays was to provide further distinctions among the older subjects. As in the six letter conditions, as exposure time increased, the number of significant differences between groups increased as well. As the exposure time increased the differences between the older and younger subjects became more significant. This finding suggests that the storage strategies demonstrated by the III-9 to V-11 groups for the six letter conditions are not generally effective in storing complex stimuli. The linearly related increases in recall and exposure time for the VI-11 and VI-12 groups seems to suggest, along with their recall superiority over the majority of the groups, the Grade Six subjects have developed effective mnemonic strategies to deal with high density stimuli. The lack of this trend in the other groups indicates that the effect of increasing exposure time appears to aid confusion rather than recall.

The criteria presented earlier as indicating a functionally developed Immediate Memory were: (1) the linear increase in recall for the high density stimuli as exposure time increased, and (2) the higher recall of the high density as compared with the low density stimulus. These criteria lead to the interpretation of the results as indicating that the VI-11 and VI-12 subjects are in the final stages of the development of Immediate Memory.

The results of this study suggest that the development of each stage of the memory model is a prerequisite to the effective development of the following stage. In the present study, Iconic Memory was measured by the amount of information available for recall. The amount of information processed, or Iconic Memory capacity, was in the final stages of development in eight year olds in Grade Three, but functionally developed in nine year olds in Grade Three. It is of interest to note that although the younger subjects (I-6 to II-8) demonstrated significant differences on Iconic Memory tasks, these differences did not occur on the Immediate Memory tasks. The development of a functionally developed Iconic Memory appears essential to the development of an effective Immediate Memory process. The criteria used in this study for indicating the development of Immediate Memory place the development of this ability at the Grade Six level.

Suggestions for Further Research

The present study has provided a normative basis for further in-depth research into the development of Iconic and Immediate Memory. A few of the possibilities are:

1. To extend the sample with Junior High and High School students to establish more information concerning the development of Iconic and Immediate Memory and their interrelationships.

2. To focus on the eight year old subjects in Grades Two and Three in an attempt to confirm and clarify the changes noted in Iconic and Immediate Memory performance.

3. To use a tachistoscope with exposure levels well below the student's recognition level to establish the speed of recognition for each subject and their Iconic Memory capacity at that level. This would permit the clarification of Iconic Memory on the variables of speed and amount of processing as age and grade increases.

4. To determine the amount of information the subjects can recall in Immediate Memory by investigating the maximum information load per element recalled as portrayed by the number of letters recalled in the present study.

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APPENDIX A

STIMULUS ITEMS USED

This section reproduces the stimulus items used in the study. The two cards used for determining Recognition Threshold are labelled as "Letters" or "Numbers". The eight pairs of stimulus cards used for examining Iconic and Immediate Memory capacity are labelled by the card and item numbers. The order of the presentation of the stimulus densities was alternated from subject to subject, as was the card pairs used. Since only six pairs of cards were used in testing any one subject, the particular card pairs used were systematically changed so that only 16 subjects received an identical card pair and stimulus density presentation order. This was done in order to reduce any possible response bias to a particular stimulus group or density condition.

F J P N W S D R L X M R
Letters

5 8 3 0 6 1 7 2 4 9 5 1
Numbers

Z B X P H L
Card 1 - 6 Letters

C S Q H P Z R X T W N V
Card 1 - 12 Letters

H W Z T D J
Card 2 - 6 Letters

S R B M F Q N L G C K P
Card 2 - 12 Letters

V D W F Q M
Card 3 - 6 Letters

H U B M X Q L G T K C Z
Card 3 - 12 Letters

K R J S G T
Card 4 - 6 Letters

N B F W Z K P L Q X M J
Card 4 - 12 Letters

N C G K F B
Card 5 - 6 Letters

X N Z R H K W V F B D G
Card 5 - 12 Letters

B J W F N C
Card 6 - 6 Letters

V C B W Z Q S K G D H F
Card 6 - 12 Letters

X T Z V L D
Card 7 - 6 Letters

G P F C M L Q S J D T B
Card 7 - 12 Letters

C Q J R X P
Card 8 - 6 Letters

S J P T L B V N X H M R
Card 8 - 12 Letters